Students' Understandings of Human Organs and Organ Systems

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Abstract

How do people develop their understanding of what is inside them? This study looks at students' understandings of their internal structure. A cross-sectional approach was used involving a total of 158 students in England from six different age groups (ranging from 4 year-olds to first year undergraduates). Students were given a blank piece of A4-sized paper and asked to draw what they thought was inside themselves. Repeated inspections of the completed drawings allowed us to construct a seven point scale of these representations. Our analysis shows the extent to which student understanding increases with age and the degree to which pupils know more about some organs and organ systems than others. While gender differences in the drawings were generally not large there were some intriguing differences in the ways males and females drew reproductive organs.

Students' Understandings of Human Organs and Organ Systems

As is widely acknowledged, and as we have reviewed elsewhere, there are many ways of gathering information about students' understandings of scientific phenomena (White & Gunstone, 1992; Tunnicliffe & Reiss, 1999a). However, despite the richness and variety of the methods used by science educators, it remains the fact that most of these methods rely on students either talking or writing about science. Such methods include oral interviewing of students (Osborne & Gilbert 1980), gathering students' written responses (Leach *et al.*, 1995), recording students' spontaneous conversations (Tunnicliffe & Reiss, 1999b) and getting students to construct written concept maps (Novak & Musonda, 1991).

Each of these approaches has its own particular advantages and disadvantages but we wanted in this study to use an approach which relied less on words. This is not because we feel that words are a minor part of learning in science. Far from it! We are fully persuaded by the large and growing literature which argues for the importance, even centrality, of language in the acquisition of scientific concepts (Bloom, 1992; Sutton, 1992; Sprod, 1997; Tunnicliffe & Reiss, 1999c).

Indeed, with the exception of an approach in which the researcher behaves as a silent observer (whether participant or non-participant) of subjects silently engaging in scientific or scientifically related activities (such as working in school science lessons, gardening, cooking or repairing a bicycle), language will inevitably be a mediator between the researcher and those who are researched - and even in such silent work, the researcher is forced to use language to record, interpret and describe findings. We hope, though, that our approach is less likely than approaches that rely on words to a greater extent than ours to disadvantage students who are very shy in conversation, students who lack certain linguistic skills and students who speak a language (or languages) other than that used by the researcher. This last point means that drawings should be of especial value for international comparative studies.

We also find considerable worth in the argument that there may be no such single thing as a person's 'understanding', different facets of which can be revealed by different methodologies. Instead, it may be that different methodologies reveal different things about the multi-dimensional complexity usually labelled 'understanding' but better recognised as 'understandings' - cf. current work on the intellectual rationale for portfolio assessment (Gipps, 1999). On this argument, the appropriateness of drawing as the eliciting device used in this study is at least as much that this provides a particular view of certain particular aspects of each student's understandings.

In this study we report on students' understandings of their own internal structures. We decided on a cross-sectional approach in which students of different ages would simply be asked to draw what they thought was inside themselves. While we do not assert or intend to imply that our approach in particular or drawings in general are necessarily superior to other ways of elucidating understandings, drawings do have certain other worthwhile features in addition to their lower reliance on the use of language.

For example, many of the subjects we studied evidently enjoyed doing their drawings and took a certain care in their production. Occasional older individuals who expressed worries about what they perceived as their 'inability to draw' were, at least to some extent, re-assured by our assertion that we were interested not in the artistic merits of their drawing but in what it revealed about their understanding of what was inside themselves.

Another advantage is the comparative ease with which a rich mass of data can be obtained. In addition, there is perhaps a certain appropriateness in asking subjects to represent (albeit in two dimensions) anatomically their own anatomy. In the language of Buckley, Boulter & Gilbert (1997) and Gilbert, Boulter & Elmer (in press), such representations can be viewed as the expressed models - that is, representations of phenomena placed in the public domain - of the students. These expressed models relate to (but do not equate with) the mental models - i.e. the private and personal cognitive representations - held by the same students.

By now a considerable literature exists about the use of drawings as a research technique in education. One important debate has centred around the extent to which children draw what they *know* about an object or array when asked to draw it as opposed to the extent to which they draw what they can actually *see* from a particular view (Willats, 1977; Beal & Arnold, 1990). Our methodology side-steps this debate in that as the students were asked to draw what they thought was inside themselves they cannot have drawn what they saw but only what they 'knew'.

As far as students' knowledge, as revealed by drawings, of what is inside themselves goes, perhaps the most thoroughly studied organ system is the skeleton (Caravita & Tonucci, 1987; Guichard, 1995; Cox, 1997; Tunnicliffe & Reiss, 1999a). Those research reports and papers that have looked at other organ systems have often reported valuable data (notably Gellert, 1962; Goldman & Goldman, 1982; Johnson & Wellman, 1982; Mintzes, 1984; Carey, 1985; Williams, Wetton & Moon, 1989; Osborne, Wadsworth & Black, 1992; Teixeira, 1998; Selles & Ayres, 1999) but there is very little work that systematically and quantitatively examines how knowledge, as revealed by drawings, of the various human organs and organ systems depends on student age.

Methodology

Fieldwork was carried out in the South of England in a primary school, a secondary school and a college of higher education. The primary school (for 4/5 to 11 year-olds) is a state Church of England aided school and is in a New Town (established after the Second World War); the secondary school (for 11 to 16 year-olds) is a state comprehensive in a rural setting; the College of Higher Education contains mainly four year Bachelor of Education students training to be primary teachers. SDT carried out the primary fieldwork; MJR carried out the secondary and undergraduate fieldwork.

Cox (1989) discusses some of the ways in which children can be asked to do drawings. We simply asked our subjects, in a whole class setting, to draw what they thought was inside themselves. Students were not examined under formal examination conditions but were told not to copy one another's work. They were given as long as they wanted (up to about 10 minutes) to complete their drawing and were asked to write their name on it. A note was also made by us of the gender of each student. Many of the students labelled their drawings. Students who asked us if they could/should label their drawings were told by us that they certainly could if they wanted to and that it was up to them. The teacher wrote labels on the drawings for children if they requested it; this was particularly the case with the 4 and 5 year-olds. In these cases the teacher only wrote words said by the child.

The fieldwork was conducted in whole class settings. In all, data were obtained from 16 Reception children (aged 4 or 5), 21 Yr. 2 children (aged 6 or 7), 33 Yr. 3 children (aged 7 or 8), 32 Yr. 6 children (aged 10 or 11), 24 Yr. 9 children (aged 13 or 14) and 32 first year undergraduates (mostly aged 18 to 20). In the primary and the secondary school, all pupils were in mixed ability groups. The undergraduates were from a teacher training institution which, of the 52 institutions in the sector, has the highest average academic qualifications of its intake in England (Barnard, 1998). The undergraduates who participated came from two separate student groups. One group of 12 were all English specialists, none of whom had studied biology after the age of 16. The other group of 20 were all biology specialists, all of whom had studied biology after the age of 16. (In England and Wales it has been compulsory since 1989 for students to study science, including biology, up to the age of 16.) The biology undergraduates all knew MJR as their lecturer; the other students in the study knew MJR or SDT only slightly if at all.

Analysis

The 158 students made a total of 158 drawings, i.e. one per student. After we had collected all the drawings, we jointly and repeatedly sorted through them, attempting to arrange them in a ranked order which we felt reflected different levels of biological understanding. Our ranking was informed both by previous work in the field - especially Osborne, Wadsworth & Black (1992), Guichard (1995) and Cox (1997) - and by our own knowledge of anatomy and English biology curricula. We were also extremely keen to provide a scoring system which gave as little credit as possible to the 'artistic' quality of the drawing and was as unambiguous as possible to score. Some of the older students professed an inability to draw well and we assured them that this did not matter. No notice was taken of the student's ages in determining the scoring system.

Eventually, we agreed on an order for the biological quality of each drawing (Figure 1). The scoring system in Figure 1 requires a definition of organ systems. We used the definitions for eight human organ systems shown in Figure 2.

The two of us then separately and independently scored all the drawings. Having agreed on the level (i.e., 1 to 7), we then, for each of the eight organ systems, decided whether or not the drawing met the criterion for that organ system. If it did, we recorded the appropriate capital letter (S for skeletal, G for gaseous exchange, etc.). If it did not, we then decided whether or not at least one organ was present on the drawing for that organ system. If one was, we recorded the appropriate lower case letter (s for skeletal, g for gaseous exchange, etc.). Each drawing was therefore effectively scored a total of 17 times, once for the overall level, once for the presence or absence of each organ system and once for the presence or absence of at least one organ in each organ system. We agreed on in excess of 95% of scorings. In those cases where our views differed, we discussed each such case until we agreed.

To illustrate our analysis, Figures 3 and 4 show two drawings by Year 6 girls. The drawing in Figure 3 is scored 4 sgndc. That in Figure 4 is scored 6 SD sgndumc. In other words, the drawing in Figure 3 has no satisfactory organ systems (as defined by us) but contains organs in the following five organ systems: skeletal, gaseous exchange, nervous, digestive and circulatory. The drawing in Figure 4 shows two satisfactory organ systems - namely, the skeletal and digestive organ systems - and seven of the eight possible organ systems - skeletal, gaseous exchange, nervous, digestive, urinogenital, muscular and circulatory - omitting only the endocrine system.

Finally, we looked at all the drawings to see how males and females represented the reproductive organs. Data were entered into Minitab and Excel for analysis. All statistical tests are 2-tailed.

Results

The Effect of Student Age on the Level of the Drawing

As one would expect, older students generally attain higher levels, on average, than do younger ones. In all there are seven different 'age' categories: Reception (Yr. 0), Yr. 2, Yr. 3, Yr. 6, Yr. 9, 1st year undergraduates who are English specialists (Yr. 14E) and 1st year undergraduates who are biology specialists (Yr. 14B). Table 1 shows how the mean level attained increases when students are drawing themselves from 2.00 for Yr. 0 students to 6.30 for Yr. 14 biology students.

However, what is also notable is that while there is a very rapid increase between Yr. 0 and Yr. 2, subsequent increases are successively smaller. Indeed, the mean levels for the Yr. 9 students and the 1st year undergraduates who are English specialists are identical (4.67). With the exception of the biology specialists (Yr. 14B) it therefore seems that the drawings flatten off at a level of between 4 and 5. Further, this level is largely reached by the time the students are just 7 to 8 years old. Thereafter, any improvements for non-biology specialists are small and not significant (Table 2).

The Effect of Student Gender on the Level of the Drawing

Table 3 provides the relevant parameters for males and females separately within year classes. There are no statistically significant gender effects. (No value for t could be calculated for the undergraduate biologists as all 20 of them were female.)

Students' Understandings of Organ Systems

Lumping together all the data, and thus ignoring differences between the drawings resulting from student age, gender or degree of biology specialism, Figure 5 shows for each organ system the percentage of students whose drawing displayed an organ system as defined above in the Analysis section. Two main findings are clear. First of all, for each of the eight organ systems, only a minority of drawings show the organ system drawn sufficiently completely to be classified by us as an organ system. By way of illustration, in Figure 3 no organ systems (as defined by us) are shown sufficiently to be classified as organ systems - indeed, none comes close. In Figure 4, though, the skeletal and digestive organ systems are shown sufficiently to be classified as organ systems.

Secondly, there are statistically significant differences between the eight organ systems in terms of how well they are represented ($\chi^2 = 82.1$, 7 df, $p < .001$). The best drawn organ systems are the digestive system and the gaseous exchange system, respectively represented in 22% and 18% of the drawings. At the other extreme, none of the drawings represented the muscular system, only 1% the endocrine system and only 2% the circulatory system.

Students' Understandings of Organs

Again lumping together all the data, and thus ignoring differences between the drawings resulting from student age, gender or degree of biology specialism, Figure 6 shows for each organ system the percentage of students whose drawing represented an organ (rather than the entire organ system) as defined above in the Analysis section. Not surprisingly, students do much better at this than at representing whole organ systems. For example, fully 93% of the drawings showed an organ (nearly always the heart) in the circulatory system, while 87% showed some portion of the skeletal system. At the other extreme, only 4% of the drawings showed a part of the endocrine system. However, we do acknowledge that this last result is undoubtedly largely caused by our very narrow definition of what counted as being part of the endocrine system. In particular, we excluded the pancreas (deemed to belong to the digestive system) and the ovaries and testes (deemed to belong to the urinogenital system).

As was the case with whole organ systems, there are highly statistically significant differences between the likelihood of students drawing organs from the different organ systems ($\chi^2 = 159.6$, 7 df, $p < .001$). There are also certain clear differences between the orderings in Figures 5 and 6, notably with respect to the circulatory system which is poorly represented as a whole system (Figure 5), yet components of which are very frequently drawn (Figure 6). Nevertheless, there is a high correlation between the rankings of how well represented whole organ systems (Figure 5) and partial organ systems (Figure 6) are ($r_s = 0.87$, $p < .05$).

Representations by Males and Females of the Reproductive Organs

Table 4 summarises, by year group, how the female students drew and/or labelled reproductive organs. Table 5 presents the same information for male students. Although the sample sizes are not very large, particularly for males (62 compared with 96 females), some interesting gender commonalities and differences do emerge. These are clearest if one looks at the data by year group:

- In Reception and Yr. 2, none of the children drew or labelled any reproductive organs.
- In Yr. 3, only two of the children - both of them boys - drew or labelled any reproductive organs.
- In Yr. 6, 44% (eight in all) of the boys drew and/or labelled reproductive organs, in every case male reproductive organs. About the same proportion or possibly more, 64% (nine in all), of the Yr. 6 girls drew and/or labelled reproductive organs but strikingly most of these (seven out of nine) drew or labelled *male* reproductive organs (e.g. Figure 7).
- In Yr. 9, just over half the girls, 54% (seven in all) drew and/or labelled reproductive organs, in every case female reproductive organs. However, only 9% (just one) of the boys drew and/or labelled reproductive organs, in that one case simply labelling the genital region "genitals."
- Comparisons among the undergraduates are rendered extremely tentative given that only three of them were males but it is perhaps worth noting that none of these three drew and/or labelled any male reproductive organ, one of them simply labelling the genital region "wedding tackle." By contrast, 83% (24 in all) of the female undergraduates drew and/or labelled female reproductive organs with a further one simply labelling the genital region "reproductive bits."

We also note that on none of the 158 drawings was a clitoris either drawn or labelled. This compares with the fact that a penis was drawn on 13 of the drawings and labelled (as "penis," "willy," "penas," "private parts" or "dick") on 10 of them. A final observation is that the female students were significantly more likely to represent internal aspects of their reproductive system than were the male students. For example, none of the males drew or labelled the epididymes whereas four of the Yr. 9 females, six of the female English undergraduates and ten of the female biology undergraduates drew or labelled fallopian tubes or oviducts.

Discussion

There is a difference between a student's mental model - what they hold inside their head - and their expressed model - which is revealed to the world. However, the only way for a researcher to understand a student's mental model of a particular phenomenon is by eliciting one or more of their expressed models of that phenomenon. In this study we elicited only one expressed model per student - for example, we did not also interview students about their drawings - and we did not probe students in any way - for example, by asking them to check whether they knew anything else and, if they did, to add it to their drawing, nor did we require them both to draw and to label their drawings. (We are now conducting a separate, longitudinal study in which pupils will be followed over a number of years and interviewed about their drawings.)

For these reasons the drawings analysed here reflect not only each student's understanding of what is inside themselves but, at least to some extent, their assumption (conscious or otherwise) of what we, the researchers, wanted to see. In this sense, it is significant that we presented ourselves as educational researchers in science situations rather than, for example, appearing as artists in the context of art lessons. Perhaps, at least partly, a consequence of this was the notable extent to which students answered the instruction to "draw what is inside yourselves" in anatomical terms. No student, for example, labelled "thoughts" or anything equivalent inside their heads, though brains were frequently drawn. Some of the younger children drew or wrote "food," for example "chips," inside themselves and one Reception girl wrote "Jesus."

Obviously we hope that each student drew much (ideally, all) of what they knew about the anatomy of their internal structure but we admit we have no formal evidence for this. Indeed, it is clear that some features of the reproductive system were omitted for reasons of embarrassment / modesty. After all, to cite an extreme instance, it is surely the case that each of the three male undergraduates knew about their penis and testes yet none drew or labelled them.

The results from the drawings analysed by age first show, unsurprisingly, that there is a general tendency for older students to score higher (as previously found by, in particular, Gellert (1962)). However, there was no improvement (ignoring the undergraduate biology specialists) on our rating of the level of the drawings after Yr. 9. Indeed, Yr. 3 pupils scored only slightly less well than Yr. 9 or English undergraduates. Noteworthy too is the fact that none of the year groups (again, excepting the undergraduate biology specialists) averaged a 5 or higher on the 1 to 7 rating. Yet a 5 is the rating when a drawing showed just one (out of a possible eight) organ system. Students who scored less than a five produced drawings with no organ systems.

Our interpretation of this finding is that despite (or even as a result of) the school biology they have received, most of these students lack much understanding of organ systems. For instance, they may know that they have bones but their drawings typically fail to show a skeletal system (simply defined as skull, spine, ribs and limbs). Equally, they may know that they contain nerves but their drawings fail to present a nervous system (i.e. brain, spinal cord and some peripheral nerve - e.g. an optic nerve). In other words, students fail to see what is inside themselves as a functioning whole. Their 'insides' rather consist of a scattered assemblage of isolated organs and incomplete organ systems.

We acknowledge that the drawings analysed here come from only three institutions so that generalisations cannot be made to the whole of the school education system in England. We, as biologists, would ideally like students not only to have a good knowledge of their various organ systems (i.e. a level 7 on our rating) but to appreciate the interconnections and interrelations of these various organ systems. After all, the skeletal system requires muscles; the muscular system requires nerves, etc.. Elsewhere, in a paper which concentrated on the skeletal system, we noted that recent changes to English and Welsh school science curricula have served to atomise scientific knowledge of the skeleton and went on to suggest ways in which students might be helped to build up a more holistic understanding (Tunnicliffe & Reiss, 1999a).

It is not the case that students are equally likely to draw the various organ systems. Far from it - as shown by Figure 5. In particular, while around a fifth of all students drew digestive systems and gaseous exchange systems, only one in fifty drew circulatory systems, only one in a hundred endocrine systems and none muscular systems. Nor is it the case that students are equally likely to draw organs from the various organ systems (see Figure 6). Perhaps the most complete previous study on children's knowledge of organs was undertaken by Gellert (1962) who used oral interviews to study 96 USA children of various ages from 4 to 16 years. However, direct comparisons of our findings with those of Gellert need to be made in the light of the fact that her study was conducted on subjects who had been hospitalised for a variety of reasons. Gellert herself commented on this fact, stating, for example, "it is likely that the relatively high frequency with which the urinary system was mentioned (39 out of 96 children listed bladder, kidney, or ureter) was partly due to the fact that many of the patients in the sample suffered from disorders of the genito-urinary system" (Gellert, 1962, p. 313).

Notwithstanding this, both Gellert (1962) and we found that even very young children typically know about bones and hearts. Interestingly, such hearts are often shaped as on Valentine's cards (e.g., Figure 8, drawn by a Yr. 9 girl). We do not know for certain whether students think that this is what a heart literally looks like or whether in some cases they are representing the heart symbolically or as a shorthand derived from cards, cartoons or advertisements. However, the fact that several of the Yr. 9 and English undergraduates drew hearts thus suggests strongly that such hearts were intentionally being depicted in a non-anatomically correct fashion.

Analysis by student gender showed no statistically significant relationship with the level of the drawing. However, more fine-grained gender analysis of students' drawings of their reproductive organs revealed some intriguing findings. It must be stressed that these cannot as yet be generalised - after all, in this study, all the students within any one age group came from just one educational institution. Nevertheless, some findings are worth commenting on. First, the fact that in Yr. 6 half the girls drew male reproductive organs rather than female, and, secondly, the fact that older males (Yr. 9 and perhaps even the undergraduates) were less likely to draw male reproductive organs than were female students of the same age.

We can be more confident about a third finding related to gender. Namely the observation that a drawing is much more likely to show a penis than a clitoris. This may not surprise many readers - after all a clitoris is far smaller than a penis. The finding fits with the observation that in England and Wales school biology and science textbooks are much less likely to talk about or illustrate the clitoris than the penis (Reiss, 1998). Indeed, the clitoris is sometimes written of as "the female's equivalent of a penis" (e.g., Mitchell, 1987, p. 109) whereas the penis seems never to be written of as 'the male's equivalent of a clitoris.' We also note that this finding and the observation that females seem more likely than males to draw only internal aspects of their reproductive system concurs with a feminist assertion that females are socialised into a discourse which sees their reproductive organs as sites simply of reproduction rather than of sexual pleasure.

Conclusions

By simply asking students of different ages to draw what is inside themselves, a considerable amount of valuable research material can be gathered. Analysis shows that by the time the students we studied were eight years old, they mostly had a broad knowledge of their internal structure, being aware of a wide variety of organs. However, they had little appreciation of how organs exist as related structures within organ systems. Dishearteningly, for science educators, older students, including even English undergraduates, had little better understanding of their organ systems than did eight year-olds as revealed by their drawings. This finding has implications both for secondary school biology education in particular and for the public understanding of science more generally.

In agreement with work carried out by previous researchers, the children studied here learnt about different organs and organ systems at different ages. Science curricula should build upon and extend the knowledge that students bring to science classes. It seems that as children age they first learn that there they contain certain individual organs. They then realise that these organs are situated in specific locations. Then they come to know that certain organs are joined together in functional units, for example the oesophagus is joined to the stomach. In some cases students then learn that a number of organs are joined into a whole organ system. From a teaching point of view this means that rather than, as often is the case at present, teaching students from the start about whole organ systems and then going into more detail about constituent organs - a model of disassembly - we might do better to begin with individual organs and then help children learn that these are assembled into functional systems. This would be a model of assembly.

Finally, this study has also shown that while gender differences between overall levels of understanding were not statistically significant, there were some fascinating differences between males and females in terms of how they represented reproductive organs in their drawings.

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Level 1	No representation of internal structure
Level 2	One or more internal organs (e.g. bones and blood) placed at random
Level 3	One internal organ (e.g. brain or heart) in appropriate position
Level 4	Two or more internal organs (e.g. stomach and a bone 'unit' such as the ribs) in appropriate positions but no extensive relationships indicated between them
Level 5	One organ system indicated (e.g. gut connecting head to anus)
Level 6	Two or three major organ systems indicated out of skeletal, gaseous exchange, nervous, digestive, endocrine, urinogenital, muscular and circulatory
Level 7	Comprehensive representation with four or more organ systems indicated out of skeletal, gaseous exchange, nervous, digestive, endocrine, urinogenital, muscular and circulatory.

Figure 1. The system used to score the biological quality of each drawing.

Skeletal system	Skull, spine, ribs and limbs.
Gaseous exchange system	Two lungs, two bronchi, windpipe which joins to mouth and/or nose.
Nervous system	Brain, spinal cord, some peripheral nerve (e.g. optic nerve).
Digestive system	Through tube from mouth to anus and indication of convolutions and/or compartmentalisation.
Endocrine system	Two endocrine organs (e.g. thyroid, adrenals, pituitary) other than pancreas [scored within digestive system] or gonads [scored within urinogenital system].
Urinogenital system	Two kidneys, two ureters, bladder and urethra *or* two ovaries, two fallopian tubes and uterus *or* two testes, two epididymes and penis.
Muscular system	Two muscle groups (e.g. lower arm and thigh) with attached points of origin.
Circulatory system	Heart, arteries and veins into and/or leaving heart and, at least to some extent, all round the body.

Figure 2. Definitions of each organ system.

Figure 3. A drawing by a Yr. 6 girl which is scored 4 sgndc according to the method described in the text.

Figure 4. A drawing by a Yr. 6 girl which is scored 6 SD sgndumc according to the method described in the text.

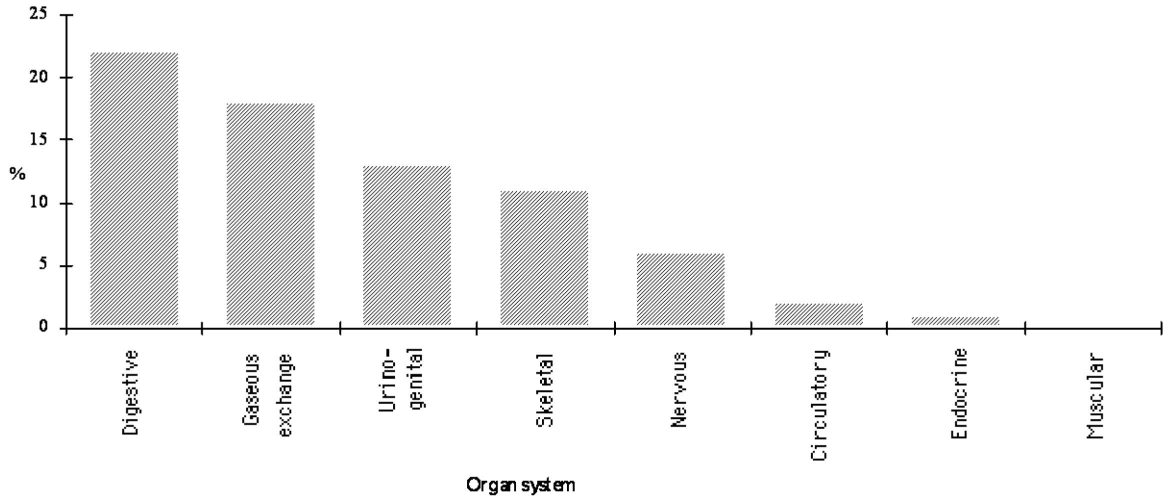

Figure 5. For each of the eight organ systems, the percentage of students whose drawing showed the organ system as defined in the text.

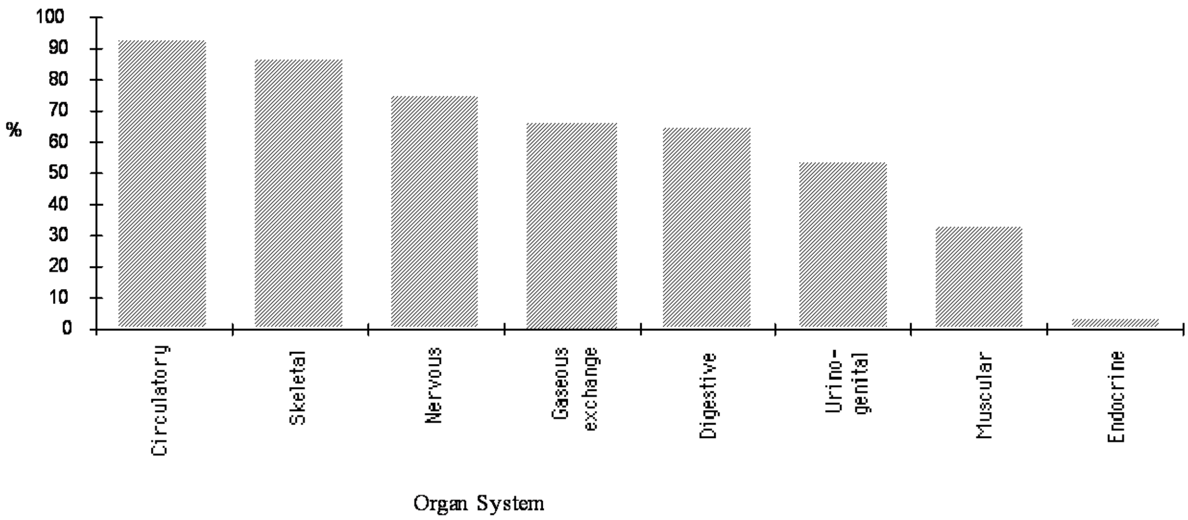

Figure 6. For each of the eight organ systems, the percentage of students whose drawing showed an organ in that organ system.

Figure 7. An example of a drawing by a Yr. 6 girl which shows and labels male reproductive organs.

Figure 8. Many of the hearts drawn were shaped as on Valentine's cards. This drawing is by a Yr. 9 girl.

Table 1

The Levels attained by Students of different Ages when Drawing Themselves

Year	Mean level	SD	n
0	2.00	0.36	16
2	3.71	0.46	21
3	4.27	0.75	33
6	4.41	0.74	32
9	4.67	0.88	24
14E	4.67	0.67	12
14B	6.30	0.72	20

Note: Levels equate to the 1-7 scale for understanding as described in the text. Yr. 0 students are Reception pupils (aged 4-5 years); Yr. 14E students are first year undergraduates specialising in English; Yr. 14B students are first year undergraduates specialising in Biology. SD is the standard deviation; n is the number of students in each age category.

Table 2

Comparison of Adjacent Year Classes to see whether the Mean Levels of the Drawings Differed

Years being compared	Value of t	df
Yr. 0 versus Yr. 2	12.58***	35
Yr. 2 versus Yr. 3	3.40**	52
Yr. 3 versus Yr. 6	0.76	63
Yr. 6 versus Yr. 9	1.18	54
Yr. 9 versus Yr. 14E	0	34
Yr. 14E versus Yr. 14B	6.56***42	

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3

Analysis of Differences in the Levels Attained by Males and Females Within Year Classes

Year	Mean level for females	Mean level for males	t	df
0	2.00	2.00	0	14
2	3.62	3.88	1.38	19
3	4.06	4.53	1.96	31
6	4.29	4.5	0.80	30
9	4.92	4.36	1.68	22
14E	4.78	4.5	0.60	10
14B	6.30	-	-	-

Note: No differences are significant at the 5% level.

Table 4

Summary, by Year Group, of how Female Students Drew and/or Labelled Reproductive Organs

Year	Number of females	Percentage of females who drew and/or labelled female reproductive organs	Percentage of females who drew and/or labelled male reproductive organs	Percentage of females who drew and/or labelled organs of indeterminate sex or of both sexes
0	9	0	0	0
2	13	0	0	0
3	18	0	0	0
6	14	7	50	7
9	13	54	0	0
14E	9	78	0	11
14B	20	85	0	0

Table 5

Summary, by Year Group, of how Male Students Drew and/or Labelled Reproductive Organs

Year	Number of males	Percentage of males who drew and/or labelled male reproductive organs	Percentage of males who drew and/or labelled female reproductive organs	Percentage of males who drew and/or labelled organs of indeterminate sex or of both sexes
0	7	0	0	0
2	8	0	0	0
3	15	7	0	7
6	18	44	0	0
9	11	0	0	9
14E	3	0	0	33
14B	0	-	-	-